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AFFTC

AP22S-2 FULL PRESSURE SUIT EVALUATION IN THE U-2 AIRCRAFT

25X1A

[redacted]
Captain, USAF
Project Pilot / Engineer

TECHNICAL DOCUMENTARY REPORT NO. 62-32
NOVEMBER 1962

AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

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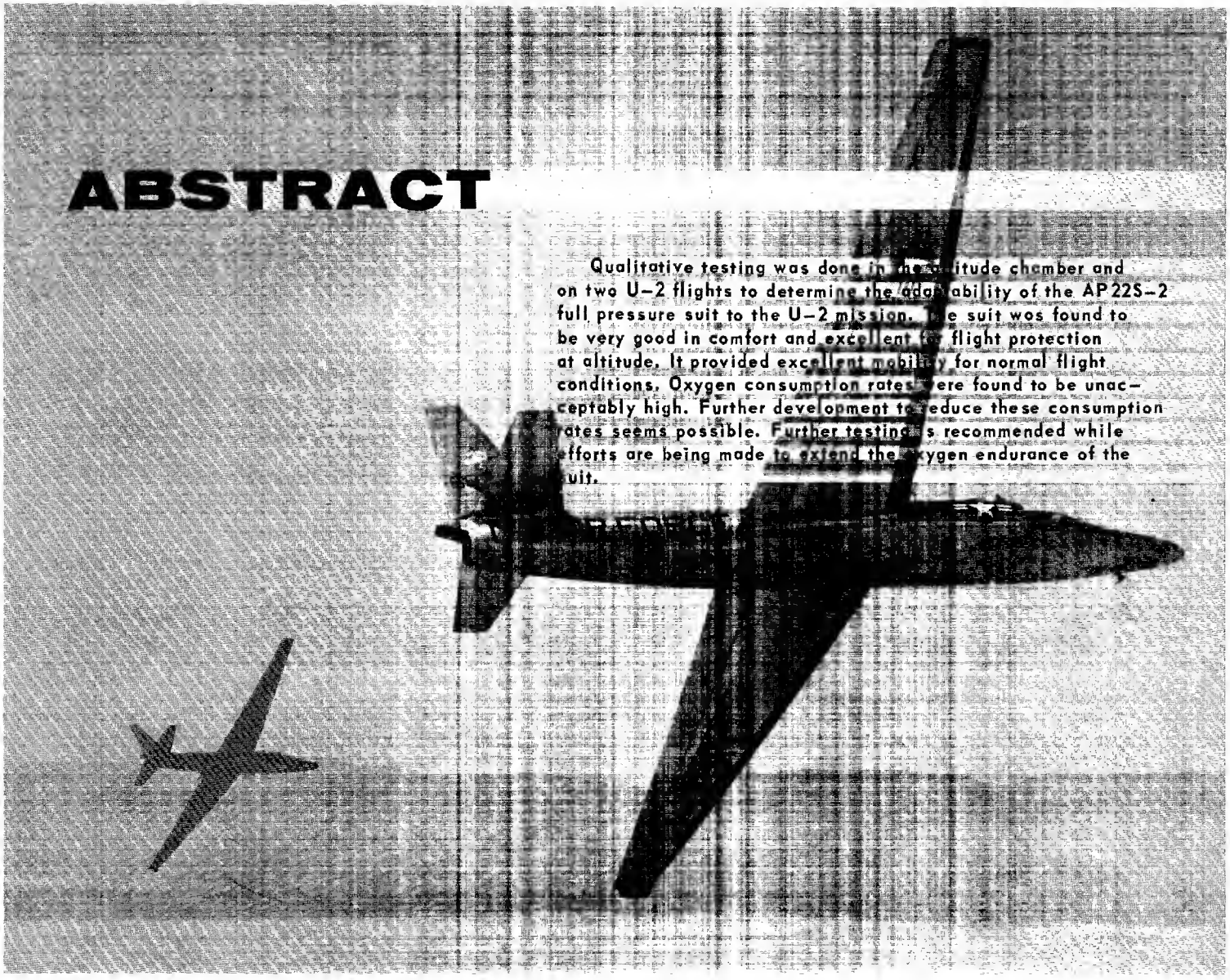

ABSTRACT

Qualitative testing was done in the altitude chamber and on two U–2 flights to determine the adaptability of the AP22S–2 full pressure suit to the U–2 mission. The suit was found to be very good in comfort and excellent for flight protection at altitude. It provided excellent mobility for normal flight conditions. Oxygen consumption rates were found to be unacceptably high. Further development to reduce these consumption rates seems possible. Further testing is recommended while efforts are being made to extend the oxygen endurance of the suit.

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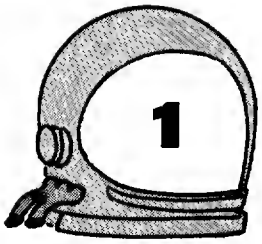
This report has been reviewed and approved

Colonel, USAF
Director, Flight Test



INTRODUCTION

Partial pressure suit missions at Patrick AFB under conditions of high temperature and humidity have identified certain problems. Most mission flights require a minimum of 50 minutes pre-breathing at ground level prior to take-off. At least 20 minutes of this time is in an ambient atmosphere. This occurs during loading into the cockpit, rolling out of the hangar, starting engines, awaiting clearance, and taxiing for take-off. Heat fatigue is intense under the conditions imposed on the pilot. Perspiration is so intense that some pilots have had a serious obstruction to vision due to perspiration entering the eyes.

The AP22S-2 full pressure has the cabability to alleviate these pre-take-off hazards. The garment can be fully ventilated with portable refrigerated air conditioners during ground operation. It is not necessary to prebreathe on most mission flights if this suit could be employed.

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With these known facts, [redacted] Chief, Special Projects Operations Branch appointed [redacted] as Project Officer and ordered an evaluation of the AP22S-2 suit to see if it would be suitable for use in all of the Flight Test Center's U-2 missions.

The AP22S-2 suit tested belonged to the X-15 program. This model incorporated an anti-g bladder which produces a little bulk. The anti-g feature would not be necessary for the U-2 mission.

The X-15 suit tested belongs to NASA and was loaned for two flights only.

2 TEST PROGRAM

COCKPIT DEMONSTRATION

25X1A [redacted] Chief of the Bioastronautics Environmental Section provided a ground cockpit demonstration in the U-2. Major 25X1A [redacted] is 6 feet 2 inches tall and weighs 195 pounds. While wearing the AP22S-2 suit, he was inflated to a full 5 psi from a console and was requested to demonstrate his mobility in the fully inflated condition. He was able to reach all of the essential switches and controls.

ALTITUDE CHAMBER CHECKOUT

On 16 November 1961, the Project Pilot checked out in the suit in the altitude chamber. The chamber was evacuated to an equivalent altitude of 125,000 feet and an explosive decompression exercise was done at the end of the run.

TF-102 AIRBORNE FAMILIARIZATION FLIGHT

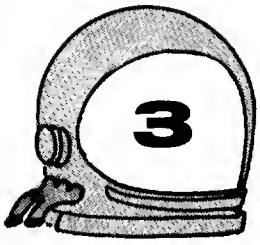
This flight added little to the evaluation. It is required by regulation prior to a first pilot pressure suit flight in any aircraft. It was flown on 28 November 1961.

U-2 FLIGHT NUMBER 1, LOW ALTITUDE

On 30 November 1961, a three hour and fifteen minute U-2 flight at 50,000 feet was made. The suit evaluation was accomplished while flying a typical weather mission which required the operation of switches at cockpit extremities. The regulator on the suit was set to pressurize at a cabin altitude of 35,000 feet.

U-2 FLIGHT NUMBER 2, HIGH ALTITUDE

On 15 February 1962, the five hour and thirty-five minute suit evaluation in the U-2 was made. It was done while flying a mission similar to Flight Number 1. On this flight the suit regulator was set to commence pressurizing at a cabin altitude of 27,000 feet. The mission was flown at peak performance altitude. The purpose of the different regulator setting was to evaluate comfort of the suit under soft blow-up conditions. This was reported to be the area of maximum comfort since it allows ventilation to all parts of the body without loss of mobility. Average differential pressure of the suit and cockpit was 0.5 psi.



3 FUNCTIONAL ANALYSIS

ADAPTABILITY

The AP22S-2 suit requires a 70 psi oxygen source, a suit ventilation blower, and face plate heat. The existing ventilation blower for the partial pressure suit is suitable for vent requirements in the AP22S-2 suit. The face heat is available through the U-2 seat kit and was easily connected. The 70 psi line between the emergency oxygen bottle and the seat kit regulator was tapped and brought out the right side of the seat kit. An extension hose was added and connected to the suit regulator on the right front of the suit. This modification was very simple and it was accomplished by chamber personnel in half a day. This did not alter the emergency oxygen supply or the procedures using the emergency system. Oxygen check and face plate heat check procedures were the same as the partial pressure suit except that the push-to-test suit blow-up button was located on the suit regulator.

DRESSING

The AP22S-2 suit is easier to get into than the partial pressure suit. Immediate suit ventilation is provided through the oxygen console and could be provided through portable refrigerated air conditioners. On the first flight, dressing and suit checkout were accomplished in five minutes without hurrying. Procedure requires entering the suit from an opening in the back. Both legs are inserted, then the top of the suit is donned in slip-over fashion. The back of the suit is zipped up. The gloves are next and they clamp on by means of a short rigid cylindrical wrist rings. The helmet is then placed on the head and fastened in a similar manner to the gloves. The helmet is free to swivel on the neck ring with head movements from side to side. The boots are donned and the suit is ready for checkout by lowering the face plate. Face plate is button actuated and lowers by gravity fall. It seals immediately.

SUIT CHECK

Suit checkout was simple. An oxygen pressure console in the dressing trailer was operated by chamber personnel. It involved pressurizing the suit to 5 psi to check for leaks in the suit.

COCKPIT HOOK-UP

Both U-2 flights were conducted on cool days so evaluation of the portable refrigerated air conditioner was not practical. No ventilation was used during the short trip from the trailer to the cockpit. Cockpit entry was easy. Hook-up to the aircraft was less complicated than in the partial pressure suit. All connections were on the right side except for the left seat kit attachment to the parachute. Suit test in the aircraft was accomplished by the push-to-test button on the suit regulator. This is not recommended in the air because there is no pressure gage to indicate the degree of pressurization. Five psi blow-up is the operational limit. When the button is released, immediate deflation occurs. Face heat check is fast. Obvious heating takes place when the cockpit rheostat is placed in the full hot position. Face plate sealing is done by the pilot. A deflection of a button on the helmet causes the face plate to drop into position and seal automatically. This allows safe momentary face plate raising while at altitude since there is no pressure opposition to face plate sealing.

PROTECTION

The suit regulator can be easily modified with two optional pressurization schedules selected by a switch. Either a 5 psi schedule (this gives an equivalent pressure of 27,000 feet) or a 3.5 psi schedule (this maintains no more than 35,000 feet equivalent pressure) is available. Both of these schedules offer more protection than the 45,000 foot equivalent skin pressure provided by the partial pressure suit.

The 5 psi schedule would eliminate the necessity of prebreathing on most mission flights. The 3.5 psi schedule would give more mobility at medium altitudes if mobility were needed.

FLIGHT PHASE U-2

Unpressurized:

The first flight in the U-2 was flown with the suit unpressurized for the first three hours. Suit fitting in the uninflated condition was similar to an ordinary flying suit. There was no restriction to required cockpit movements to accomplish the weather mission. Mobility in the deflated state is considerably better than in the partial pressure suit.

Soft Inflation (28,000 Feet):

On the second flight the objective was to evaluate the suit for a long mission flight with the regulator set to commence pressurization at 27,000 feet. The average inflation of the suit was about 0.5 psi. The mobility of the suit in this condition was good. No restriction was noticed in reaching any switch in the cockpit. Full suit ventilation was possible at all times in this state.

Hard Inflation (49,000 Feet):

At the end of the first flight, the cabin pressurization was failed at 49,000 feet. The suit was pressurized hard at about 2 psi cabin-to-suit differential. Mobility was not as good as the partial pressure suit pressurized at this altitude. It should be pointed out that the partial suit commences its schedule at 45,000 feet and is very lightly inflated at this point. Comparisons in the altitude chamber disclosed that at altitudes of about 55,000 feet and over, the full pressure suit surpasses the partial pressure suit in mobility. The pressure in the cabin was failed again on the second flight with the suit regulator set at 27,000 feet. This created a differential of about 3.2 psi between the suit and cabin pressure. The suit did not seem noticeably less mobile than the 2.0 psi differential blow-up on the first flight. However, ten weeks had passed between flights and the comparison may not be considered entirely valid. On both of the above flights the pilot was able, with some effort, to reach the

defrost fan switch. This switch is located on the left side console toward the rear and could be important in a flamed-out condition.

Notable Functional Advantages:

1. The visibility of the full pressure suit is noticeably better than in the partial pressure suit. The neck ring swivels easily with the suit inflated or deflated to increase this vision advantage.

2. It has more mobility than the partial pressure suit when unpressurized and when pressurized above 55,000 feet (based on results of altitude chamber evaluation).

3. Prebreathing is not necessary on most missions flown by the U-2.

4. The face plate of the full pressure suit unseals automatically and allows ambient air to enter the helmet when the oxygen is exhausted. This could save the life of a pilot who is unconscious due to a crash or a bailout.

5. Face heat was more effective and cleared away fog faster than the partial pressure suit.

6. The ejection handle could be reached in flight at an inflation of 3.2 psi. This was demonstrated also to maximum inflation of 5 psi by [redacted] during ground demonstration of the suit. 25X1A

7. The face plate is quickly and safely raised and lowered and can be done successfully at any cabin altitude.

Notable Functional Disadvantages:

1. There is less mobility than a partial pressure suit in the altitude range from 30,000 feet to about 55,000 feet.

2. Oxygen consumption rate is approximately double that of a partial pressure suit. The second U-2 flight was planned to be of eight hours duration. The oxygen supply was nearly exhausted at the end of 5½ hours. A leak test was run on the system. A small leak was found in the helmet but it only caused about a 30 minute loss in the oxygen supply.

4 OPERATIONAL ANALYSIS

PREFLIGHT COMFORT

The ease of dressing in the suit and the full ventilation garment gives this suit more preflight comfort than an ordinary flight suit. With a portable air conditioner, last minute operational details, aircraft preflight, mission changes, etc., can be accomplished in any outside environment. If prebreathing is not required, verbal contact with technicians and other mission personnel is possible. This is one of the main advantages of the AP22S-2 suit.

IN-FLIGHT COMFORT

On the first flight of 3:15 hours duration many small benefits in comfort were noticed. The face seal in the helmet was considered more comfortable than the neck seal. For short flights a loose fitting suit is more comfortable than the tight fit of the partial pressure suit. Body comfort, considering temperature, is about equal in the two suits. Since the ventilation blower uses cockpit air as its cooling source, this was expected. When the suit was inflated

the pilot was free to move about inside the rigid walls of the suit. This allows ventilation to get all around and cool off the posterior after sitting on one spot for a long period.

Helmet:

During the altitude chamber check-out, the pilot was given a helmet that was very uncomfortable. When the neck ring was fastened his neck seemed to be compressed and there was a great deal of pressure on the top of his head. After the chamber run this was discussed with the chamber personnel that this was very uncomfortable and would be unacceptable on a long flight. They demonstrated an improved version of the helmet which was lined with foam rubber and seemed to allow more vertical head room. This helmet was worn on the first U-2 flight and comfort was good. The same helmet was worn on the seond flight. There was masking tape on the ear phones, however, and this proved to be very troublesome. It was uncomfortable from the first and by the end of the flight the pilot's head was throbbing. His head was sore for about five days after the flight where the masking tape pressed into the skull just above the ears. This demonstrates that helmet fit in this suit is critical for flight comfort. A soft foam rubber shell could be used for better operational flexibility.

Gloves:

The gloves are a weak point in the suit. Ventilation does not seem to reach the hands. The result is constant sweating inside the rubber lining. After each flight the pilot's finger tips were wrinkled as if they had been in water for a long period of time. Perhaps a thin fabric glove insert would help this situation in the same way that socks absorb foot moisture. Finger touch is compromised when the suit is inflated. The gloves inflate and it is awkward to activate switches that require a delicate finger touch. Bending of the fingers is possible. A strap around the palm and knuckles of the glove restricts expansion somewhat. The contractor stated that the gloves the pilot wore were too large and that a tailored pair would have helped the situation.

Boots:

Any boot is acceptable for wear with this suit. The boot should be about two sizes larger than normal foot wear to allow for suit expansion around the feet.

Suit:

The suit is generally more comfortable for flights of short duration. On the 5:35 hour flight the comforts previously listed were somewhat diluted. This is because small comforts seem relatively unimportant when the body is fatigued. It should be considered that the helmet irritation on the long flight made everything else seem quite unimportant. It was very aggravating and it received a lot of attention and head movement within the helmet to alleviate it. It was necessary for the pilot to constantly rotate his head inside the helmet to move the earphones off of the hot spots that were developing on his head.

5 DEVELOPMENT POSSIBILITIES

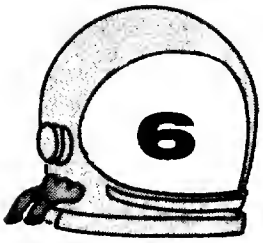
Oxygen consumption rate in the AP22S-2 suit appears to be about double that of the partial pressure suit. This has been determined from the results of one U-2 flight. Data on consumption rates of this suit from chamber tests have not been collected as of this date. The Bioastronautics Branch has been requested to collect data on consumption rates for this suit at various altitudes in the altitude chamber.

Consumption rates have been determined in a similar suit called the Mark 2. This suit was used on early flights of the X-15. Bioastronautics engineers expect similar consumption rates on the AP22S-2 suit. The results of MK-2 consumption rates indicate a six hour oxygen supply in the U-2. The 5:35 hour flight in the U-2 reflects the similarity in oxygen usage.

The David Clark Company, the AP22S-2 manufacturer, has received the problem of this excessive oxygen consumption. They believe that a modification of the breathing regulator can extend the endurance of this suit. The regulator and exhalation valve were designed to operate in the hostile environment of nitrogen. This encouraged ultra safety measures to be certain that nitrogen gas would not get into the breathing oxygen through exhalation valves. The breathing regulator was designed to deliver 125 liters per minute of oxygen to the helmet to insure positive pressure against the nitrogen atmosphere. The partial pressure suit regulator provides 90 liters per minute. The contractor believes that a modification of the breathing regulator can be accomplished within Air Force Specifications to extend the endurance of the AP22S-2 suit in the U-2.

This modification is not difficult and it is intended that such a modified regulator be used in the future consumption tests.

Firewell Corporation, the regulator manufacturer, has been consulted and they will be monitoring these tests.



6 CONCLUSIONS

1. The AP22S-2 full pressure suit is not acceptable at this time for all around mission accomplishment in the U-2. In its present configuration, six hours of oxygen supply is the maximum to be expected.

2. It offers certain in-flight comfort not available in partial pressure suits.

3. It is less flexible than the partial pressure suit at cabin altitude of 40,000 to about 55,000 feet, but it is more flexible at all other altitudes.

4. Finger touch is reduced but acceptable in the pressurized condition.

5. It can be pressurized to an equivalent pressure of 27,000 feet. This represents a significant increase from the 45,000 feet equivalent protection afforded by the partial pressure suit. With a 5 psi schedule available, prebreathing would not be required on most mission flights. A switch is available to the pilot to select either a 5 psi or 3.5 psi schedule, depending on operational necessity.

7 RECOMMENDATIONS

1. That final evaluation of the AP22S-2 suit be accomplished after tests and possible modifications are made to extend the oxygen endurance of the suit.

2. That two or more AP22S-2 suits be obtained for extensive qualitative testing by three or more pilots to provide evaluation for all possible flight profiles in the U-2.

Air Force Flight Test Center, Edwards AF Base, Calif. Report No. FTC-TDR-62-32, AP22S-2 FULL PRESSURE SUIT EVALUATION IN THE U-2 AIRCRAFT. Final Report, November 1962, 8 p. incl. illust. and tables.

Unclassified Report

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Qualitative testing was done in the altitude chamber and on two U-2 flights to determine the adaptability of the AP22S-2 full pressure suit to the U-2 mission. The suit was found to be very good in comfort and excellent for flight protection at altitude. It provided excellent mobility for normal flight conditions. Oxygen consumption rates were found to be unacceptably high. Further development to reduce these consumption rates seems possible. Further testing is recommended while efforts are being made to extend the oxygen endurance of the suit.

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2. Altitude Chamber Evaluation of the AP22S-2 Full Pressure Suit

I. [redacted] USAF

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